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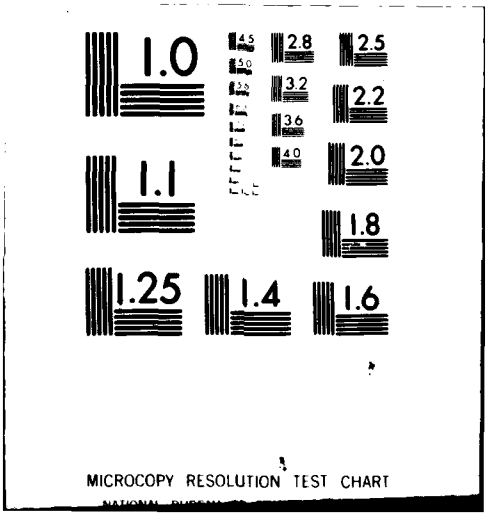
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SEGMENTATION AND SHAPE ANALYSIS FOR TRACKING IN TV VIDEO

FINAL REPORT

Owen R. Mitchell

April 15, 1981

U.S. Army Research Office

Contract Number DAAG29-80-C-0123 4

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(18) ARO (19) 17181.4-MA-EL

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO. AD A098181

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)

(6) Segmentation and Shape Analysis for Tracking in TV Video.

5. TYPE OF REPORT & PERIOD COVERED (9) Final Report. 15 Apr 80-14 Jan 81

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)

(10) Owen R. Mitchell
Purdue University

8. CONTRACT OR GRANT NUMBER(s)

(15) DAAG29-80-C-0124

9. PERFORMING ORGANIZATION NAME AND ADDRESS

Purdue Research Foundation
Hovde Hall
West Lafayette, IN 47907

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS

(11) U. S. Army Research Office
Post Office Box 12211
Research Triangle Park, NC 27709

12. REPORT DATE
15 Apr 81

13. NUMBER OF PAGES

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)

(12) 7

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

NA

18. SUPPLEMENTARY NOTES

The view, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Shape description, Fourier descriptors

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Techniques of automatically segmenting tactical targets from their background in image data and then classifying the extracted shapes have been explored. The segmentation method uses grey level, edge content, and texture. Primary research emphasis has been on improving the method of shape analysis using Fourier descriptors. A new method of classification in Fourier descriptor space has been implemented which allows quicker and more accurate library searches while requiring less storage. Also the concept of partial shape description has been further developed during this research period.

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I. PROBLEMS STUDIED

The purpose of this research was to develop improved algorithmic methods for automatically recognizing tactical targets in TV video imagery. This problem can be divided into two parts: (1) segmentation of objects from their background; and (2) recognition of the segmented objects. Although some work was done on improving segmentation methods, the major effort of this research was on the second problem, shape recognition, especially the use of Fourier descriptors for shape recognition.

II. IMPORTANT RESEARCH RESULTS

A. Adaptive Segmentation of Objects from their Background.

An approach was developed for locating and segmenting objects from their backgrounds. The objects were assumed to differ from the background in grey level, edge content, or texture. The algorithm locates unique regions of the image and then, using an expanding set of concentric annuli, locates the exact region of uniqueness, thus segmenting the object from its background. These results are reported more completely in Reference [1] which was included in the previous Progress Report submitted for this contract.

B. Fourier Descriptor Improvements

Prior work using Fourier descriptors has shown these to be particularly useful for recognizing the type and orientation of aircraft as seen in TV imagery. References [2] and [3] give details on this method. Reference [3] was published during this research period and

was included in the previous Progress Report submitted for this contract.

The Fourier descriptor method involves tracing the contour of an unknown object; filtering to remove quantization noise due to the finite resolution of the TV imagery; taking a Discrete Fourier Transform of the contour data; normalizing the Fourier coefficients with respect to scaling, translation, and rotation; and comparing the normalized coefficients (the Fourier descriptor) with library entries of known shapes. Two additional improvements were next made: (1) an eigenvector transformation which removes the redundancy in the coefficients and reduces the amount of data required for each library entry to 12 integers, and (2) the ability to interpolate between library entries so that classification accuracy is improved without adding additional library entries.

During this research period, much emphasis has been placed on improving the classification procedure. Based on work done originally by Kuhl [4] a new method of ordering and storing the library Fourier descriptors has been implemented. Since each Fourier descriptor is represented by 12 integers, it can be considered to be a point in 12-dimensional space. Each view of an object (caused by changes in yaw and roll) can be represented by another 12-dimensional vector. In fact as the object changes orientation, it sweeps out a surface in this 12-dimensional space which represents every possible Fourier descriptor vector which can represent this object. This surface is the "library" for this object.

Our research in this area has concentrated on finding good methods of representing this surface and searching an unknown vector to see if it is close to the surface. We have developed methods of sampling

the surface and ordering the samples so that the total Euclidian distance in 12-dimensions between the ordered samples is almost optimally minimum. The surface is then represented by a 12-dimensional chain code representing the connection of sample points on the surface. Initial experiments have found that this method of storing libraries requires less memory than storing every 12-dimensional vector as was done previously. The classification accuracy has increased slightly (due to a more optimum surface sampling). The speed of the library surface is improved because the distance measure can be updated from one sample point to the next instead of having to be entirely recalculated.

We feel this new method has good potential but needs additional research before a final implementation method is fixed. One area which needs research is the normalization methods. The technique of normalization with respect to rotation has some ambiguities involved and results in surface discontinuities in the 12-dimensional Fourier space. Other normalization methods need to be considered which would give fewer discontinuities and thus result in more compact library representation.

C. Partial Shape Descriptors

Often either obscuration or a poor segmentation results in a partial contour instead of a complete one. We have been developing shape description methods which can recognize partial contours. The first results of this are reported in Reference [5] which will be published in May 1981. Work in this area is in progress but no

significant results have yet been obtained other than those in [5]. This reference describes a shape descriptor based on distances from one point of maximum curvature to the next and total angle change from one point of inflextion to the next on the contour.

D. References for Section II.

[1] O.R. Mitchell and S.M. Lutton, "Adaptive Segmentation of Unique Objects," Proc. Fifth Inter. Conf. Patt. Recogn., Miami Beach, FL., pp. 548-550, Dec. 1-4, 1980.

[2] T.P. Wallace and P.A. Wintz, "An Efficient Three-Dimensional Aircraft Recognition Algorithm Using Normalized Fourier Descriptors," Computer Graphics and Image Processing, vol. 13, pp. 96-126, 1980.

[3] T.P. Wallace and O.R. Mitchell, "Analysis of Three-Dimensional Movement Using Fourier Descriptors," IEEE Trans. on Pattern Analysis and Machine Intelligence, Vol. PAMI-2, pp. 583-588, Nov. 1980.

[4] F. Kuhl and R. Covelli, "Object Identification by Multiple Observations of the Scattering Matrix," Proc. of IEEE, vol. 53, pp. 1110-1115, Aug. 1965.

[5] T.P. Wallace, O.R. Mitchell, and K. Fukunaga,"Three-Dimensional Shape Analysis Using Local Shape Descriptors," to appear in IEEE Trans. on Pattern Analysis and Machine Intelligence, May 1981.

III. Publications

Manuscripts published under ARO sponsorship during this period:

[1] T.P. Wallace and O.R. Mitchell, "Analysis of Three-Dimensional Movement Using Fourier Descriptors," IEEE Trans. on Pattern Analysis and Machine Intelligence, Vol. PAMI-2, pp. 583-588, Nov. 1980.

[2] O.R. Mitchell and S.M. Lutton, "Adaptive Segmentation of Unique Objects," Proc. Fifth Inter. Conf. Patt. Recog., Miami Beach, FL., pp. 548-550, Dec. 1-4, 1980.

[3] O.R. Mitchell, E.J. Delp, T.P. Wallace and W.K. Cadwallender, "Computer Analysis of Speckle Shearing Images," Proc. Fifth Inter. Conf. Patt. Recog., Miami Beach, FL., pp. 361-363, Dec. 1-4, 1980.

[4] T.P. Wallace, O.R. Mitchell, and K. Fukunaga, "Three-Dimensional Shape Analysis Using Local Shape Descriptors," to appear in IEEE Trans. on Pattern Analysis and Machine Intelligence, May 1981.

IV. Participating Scientific Personnel

Graduate Students

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D.J. Charpentier

Faculty

O.R. Mitchell

No degrees awarded to these people during this time period.